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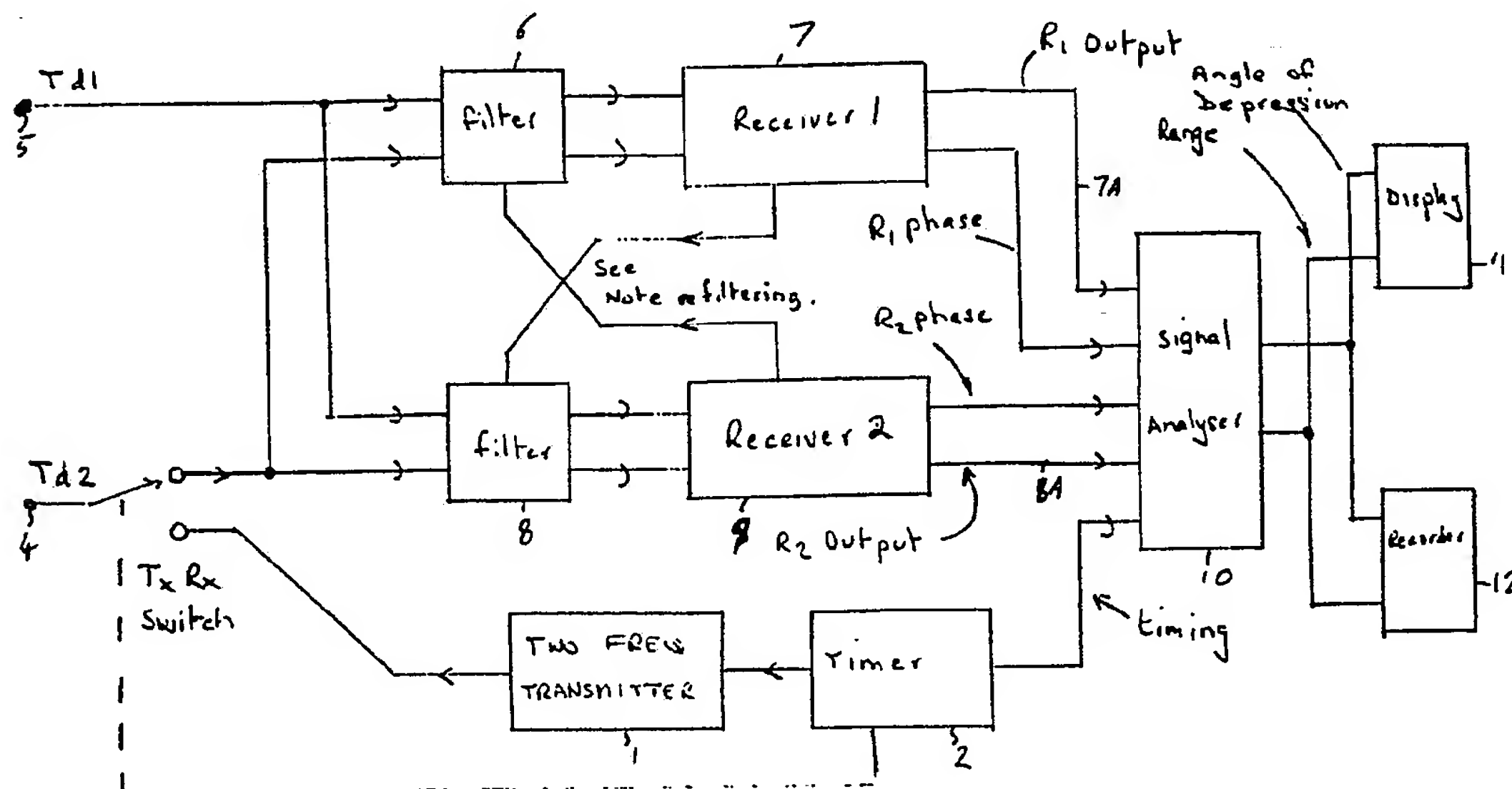
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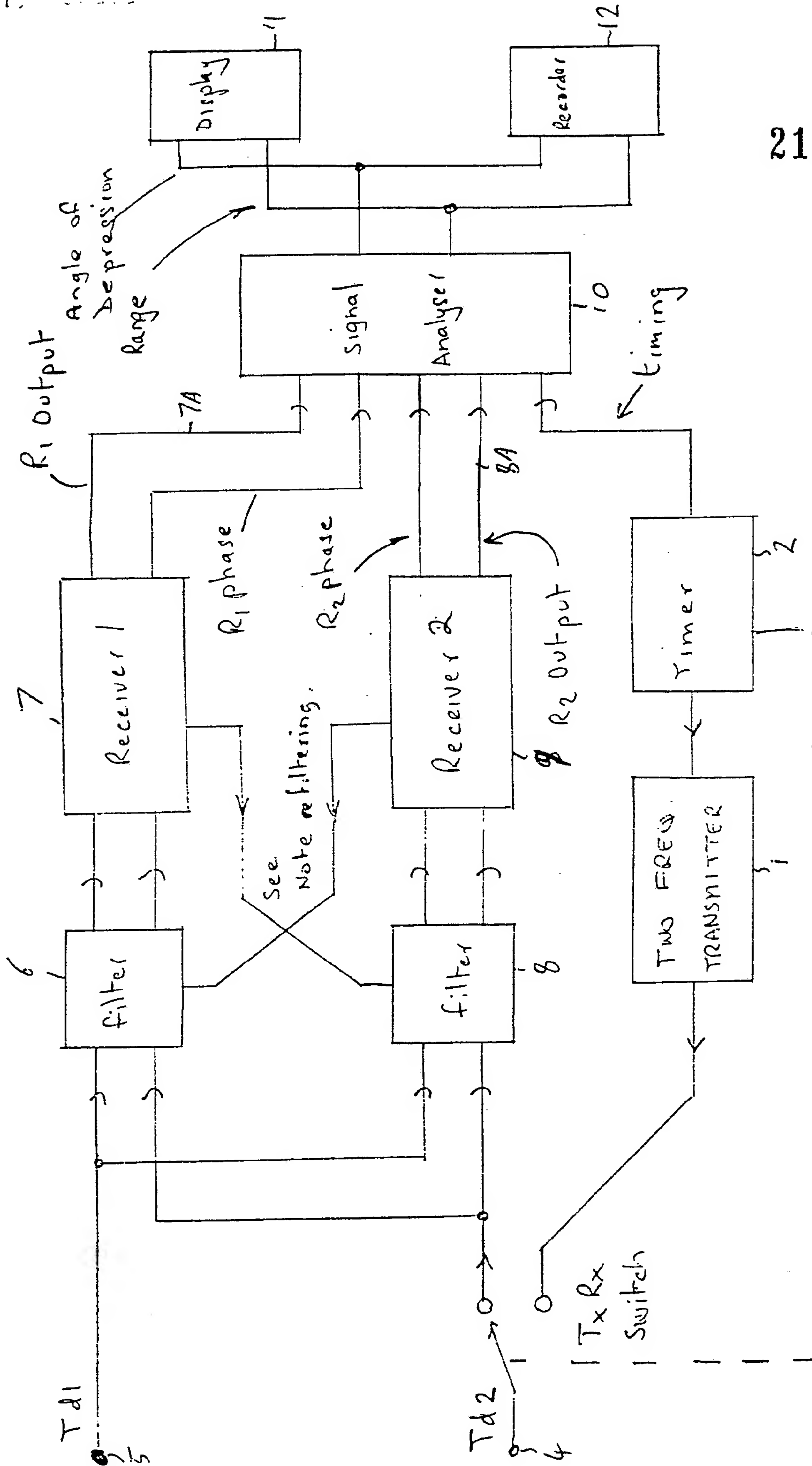
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(54) Acoustic echo-sounding system

(57) An echosounding system illuminates an area of sea-bed with acoustic energy which is received at two receiving transducers 4, 5. The relative phase of the transducer outputs indicates the direction of a feature from which an echo is received but there is a directional ambiguity due to a lobe structure of the system's sensitivity pattern. This ambiguity is resolved by transmitting at two or more different frequencies giving respective different lobe structures. The frequencies are transmitted alternately or simultaneously and Filters 6, 8, in the receiving means separate the resulting signals. Analyser 10 calculates range and direction.



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An Echosounding System

This invention relates to an echosounding system of the type comprising transmitting means for transmitting sound energy at a particular wavelength and receiving means for receiving the said energy, after reflection from features of interest, at two different points spaced by a distance comparable with the said wavelength so as to make the receiving means most sensitive to energy received from a certain group of spaced directions or "lobes".

A system of the aforementioned type is described in a paper by Cloet et al entitled "A sideways-looking Towed Depth-measuring System" published in the Journal of the Institute of Navigation September 1982 Vol 35 No. 3. Such a system requires three transducers at different points, the third transducer being necessary to resolve directional ambiguity arising from the presence of more than one region of sensitivity in a simple two-detector arrangement.

The need for a third detector involves additional expense and in some circumstances it may be difficult to make available the necessary space for it. This invention arose with a view to overcoming these problems.

According to the invention there is provided an echosounding system comprising transmitting means for transmitting sound energy at a particular wavelength and receiving means for receiving the said energy, after

reflection from features of interest, at two different points spaced by a distance comparable with the said wavelength so as to make the receiving means most sensitive to energy received from a certain group of spaced directions characterised in that the transmitting means is designed to transmit at a second wavelength sufficiently different from the first mentioned wavelength to make the receiving means most sensitive to signals received from a second group of spaced directions.

By employing two wavelengths two respective lobe patterns are produced. Ideally only the main lobes of respective patterns will co-incide and it is therefore possible to remove the aforementioned ambiguity. In practice there may be some other lobes which co-incide. If so, any remaining ambiguity can be removed by employing three or more different frequencies.

The two frequencies can be transmitted alternately but it is considered more efficient to transmit them simultaneously and to use filters in the "receiving means" to separate the resulting signals.

One way in which the invention may be performed will now be described by way of example with reference to the accompanying drawing of a sea-bed mapping system constructed in accordance with the invention.

The illustrated system is located in an instrument designed to be towed behind a ship at a predetermined depth below the sea surface. A transmitter 1, controlled

by a timer 2 produces electrical pulses each having two frequency components f_1 and f_2 both being in a region around 300 kHz. During the generation of each pulse the timer 2 holds a switch 3 in the position shown by the broken line enabling the pulse to be applied to a transducer 4 thereby launching sound energy (in practice this may be ultrasonic) towards the sea-bed. After transmission of a pulse the timer 2 returns the switch 3 to the position shown by the continuous line.

Energy reflected from features on the sea-bed is received by the transducer 4 and by a second transducer 5 which is located close to the transducer 4; and being about thirteen times the wavelength of the sound energy.

The components at frequency f_1 of the received signals are passed by a filter 6 to a receiver 7 and the components at frequency f_2 are passed by a filter 8 to a receiver 9.

The receiver 7 has two outputs, 7A and 7B. On output 7A a signal is produced representing the mean amplitude of the signal received at 4 and 5. On the other output 7B is produced a signal representing the relative phase of the signals from the two transducers. This relative phase indicates the direction of the point of reflection relative to one of the sensitivity lobes e.g. as shown at L1. These are the directions for which the path length difference for transducers 4 & 5 is an integral multiple of half the wavelength equivalent to frequency f_1 . The

directional information from receiver 7 is therefore ambiguous. However this ambiguity can be resolved using the outputs 8A, 8B from receiver 8 for which the directional ambiguity arises from a different set of lobes in directions L2 only one of which co-incides with a lobe L1.

The signal analyser 10 receives a timing signal from the timer 2 enabling it to calculate the range of a feature from which a reflection is received, in addition to its direction. This information is then passed to a display 11 and recorder 12.

The two frequencies f_1 and f_2 are closely spaced and so filtering is required in the receivers 7 and 9. The filtering process includes a cross-feeding of signals between the channels as a part of a cancellation process thus taking advantage of the prior knowledge of the interfering signal to improve the quality of filtering.

It is to be appreciated that whilst the use of phase detectors (incorporated in the analyser 10) are called for in the described embodiment, beam interpolation may be operated on an amplitude basis and the angular position of the scatterers subsequently determined. This could be accomplished by re-arranging the receiver system so that the receiver outputs are proportional to the algebraic sum of the two inputs thus making the amplitude of the output dependent on the phase difference of the two inputs. By the addition of a ninety degree phase shift at one of the

receiver inputs an interleaved set of otherwise similar grating lobes for comparison purposes may be formed thus allowing beam interpolation to be made by amplitude methods. It is possible to operate such a scheme as a parallel operation with separate receivers for the additional sets of grating lobes or in a sequential manner by rapid switching in and out of the additional phase shifters.

With both phase comparison and amplitude comparison systems the inherent accuracy in determination of the angle of depression will vary in a cyclic manner within the grating lobes. There will therefore be regions of higher and lower intrinsic accuracy. The overall accuracy of the system may be improved by adding a third frequency and hence third set of grating lobes, thus producing redundant information. A selection may now be made in the determination of the angle of depression from the optimal data that is obtainable from the three sets.

The use of an additional frequency and sets of grating lobes may also be applied to the three transducer system described in the foregoing paper. In that case the use of the second frequency would permit four patterns of grating lobes to be produced and the angle of depression of each scatterer to be assessed more accurately.

In another possible modification to the illustrated system the signals from the two-frequency transmitter could be applied to both transducers. Another possibility

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would be to use two transmitters operating at respective frequencies f_1 and f_2 and connected to the respective transducers 5 and 6.

CLAIMS

1. An echosounding system comprising transmitting means for transmitting sound energy at a particular wavelength and receiving means for receiving the said energy, after reflection from features of interest, at two different points spaced by a distance comparable with the said wavelength so as to make the receiving means most sensitive to energy received from a certain group of spaced directions characterised in that the transmitting means is designed to transmit at a second wavelength sufficiently different from the first mentioned wavelength to make the receiving means most sensitive to signals received from a second group of spaced directions.
2. An echosounding system according to claim 1 in which the transmitting means is designed to transmit both wavelengths simultaneously and in which the receiving means includes filter means for separating signals derived from these respective wavelengths.
3. An echosounding system according to claim 1 or 2 in which the transmitting means includes two transmitters adapted to generate signals corresponding to the said two wavelengths and connected to feed their outputs to the respective transducers.
4. An echosounding system substantially as described with reference to the accompanying drawing and substantially as illustrated therein.